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Geologic Application of
thermal-inertia mapping from satellite

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16. Abstract The significant results from this reporting period are: acquisition of low altitude USGS thermal scanner data in the Powder River Basin, acquisition of radiometric and meteorological data from three stations in the Powder River Basin, and further evaluation of a more accurate expression of thermal inertia in terms of relative thermal inertia measurements and ground station data.			
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Figure 2. Technical Report Standard Title Page

A. Problems

We established three ground meteorological stations in the Powder River Basin, and we overflew the area with our thermal scanner. We also requested priority on the acquisition of HCMM data. Unfortunately, Skylab operations preempted this data acquisition on the afternoon of July 25, which coincided with our flights. We did not learn of this until the field mission had terminated and the ground stations were removed. This problem can be avoided next time if (1) we can verify that the HCMM data have been acquired before terminating our mission, and (2) NASA promptly notifies us of preemptions on our priority HCMM overpasses.

No HCMM satellite data have been made available to us or any sample computer compatible tapes for development of our image processing procedures.

Some noise was present on the aircraft thermal scanner data acquired at the beginning of our flights. The problem was traced to a noisy engine alternator and corrected for the remaining flights. Data acquired toward the end of the mission will require transient analysis due to the presence of cloud shadows and may have limited utility.

B. Accomplishments

Approximately 400 miles of low altitude scanner data were acquired over the Powder River Basin between July 25 - 28. The flight lines covered both altered and unaltered soil in areas of known uranium deposits, facies changes, clinker areas, underground fires associated with coal deposits, and several calibration targets (large lakes, large homogeneous ground). These flights were centered around the HCMM overpass times of 2:30 a.m. and 1:30 p.m. local solar time.

Three ground stations were established prior to the flights: one near the Sheridan underground coal fires, one in the Pumpkin Buttes uranium area, and one near Pathfinder Reservoir (one of the calibration sites). The stations were separated by approximately 100 miles and should give us data representative of most our test site. Two of the stations were equipped to measure incident solar radiation (0.28 to 2.8 μm), incident long-wave terrestrial radiation (4-50 μm), air temperature and relative humidity, and wind speed and direction. In addition a normal incidence pyrheliometer was used to measure the direct solar radiation in the 0.28 to 2.8 μm region at Pumpkin Buttes. The third site was equipped with a total solar radiometer and a long-wavelength radiometer. We were not able to borrow the rocketsonde and receiving station we had anticipated. However, we were able to obtain rocketsonde data (atmospheric pressure, air temperature, and dew point depression) for the week of July 23 rd from the five National Weather Bureau stations that surround the Powder River Basin. These data will be used as input to the NASA atmospheric transmission model. The model results and the radiometric lake temperatures will be used to convert the satellite and aircraft data to ground radiant temperatures.

In the last quarterly report (March - May 1978), we proposed a potentially more accurate expression for absolute thermal inertia. The expression in that report is incomplete and should read as follows:

$$P = \alpha \cdot P_{\text{rel}} + \beta \cdot P_{\text{rel}}^{-1} + \gamma$$

where P = thermal inertia

$$P_{\text{rel}} = (1-A) / \Delta V$$

ΔV = day-night temperature difference

A = albedo

α, β, γ = coefficients which are functions of site parameters and topography.

A set of P_{rel} values were generated for latitudes ranging from 30 to 50 degrees and for thermal inertias ranging from 1000 to 4000 TIU*. These data sets were generated for the HCMM times of 2:30 a.m. and 2:30 p.m. and the P_{rel} 's were least squares fit to P using three expressions: proportional, linear, and non-linear (mentioned above). The standard deviations of predicting P for each of the least squares fits were examined. For this limited set of site parameters, the standard deviation of predicting thermal inertia using the proportional model was approximately 175 TIU. For the linear model, the standard deviation was approximately 15 TIU. The standard deviation for the non-linear model was approximately 2 TIU. Other data sets were generated using noon and midnight times for calculating temperature difference and using both the linear Fourier series and the Laplace transform algorithms for predicting surface temperature. The resulting standard deviations were of the same magnitude and in the same order of accuracy as the test results mentioned above. We conclude that our new non-linear model provides a very precise fit and will be appropriate for high thermal resolution studies. The linear model will probably be accurate enough for most HCMM analysis, however, and the proportional fit will be satisfactory where low thermal-inertia differences are present.

The objectives planned for the next quarter will include reducing the ground station data acquired in July, image processing of selected USGS low altitude scanner data, and re-establishing our ground stations for the seasonal comparison studies. We are also planning to review and examine the first HCMM screening products and place our first orders for computer tapes.

* $1 \text{ TIU} = 1 \text{ (W} \cdot \text{s}^{1/2} / \text{m}^2 \cdot \text{K)}$

C. Significant Results

The significant results from this reporting period are:

- Theoretically evaluated the proportional and linear relationship between absolute and relative thermal inertia and proposed a more accurate expression for thermal inertia in terms of relative thermal inertia.
- Acquired approximately 400 miles of low altitude scanner data over the Powder River Basin between July 25-28.
- Acquired radiometric and meteorological data from three ground stations in support of the low altitude USGS overflights.

For details of these results, see the accomplishments section.

D. Publications and Presentations

Ken Watson made a presentation at the Geosat meeting in Flagstaff, Arizona in June. The presentation was titled Applications of thermal data to geologic studies. Ken also presented eight invited lectures on "Thermal phenomena and energy exchange in the environment" at the Principes Physique et Mathématiques de la Télédétection, sponsored by the Centre National D'Etudes Spatiales and held at the University of Strasbourg. The lecture notes will be published shortly.

E. Recommendations

We recommend that USGS and NASA establish better communications on schedule changes of priority HCMM overpasses. See problems section.

F. Funds Expended

Total expenditures to date: \$29,125

G. Data Utility:

No U2 or HCMM satellite data have been made available to us.